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AGRICULTURAL MEMORANDUM No. 938

Windmills for pumped drainage

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A sand/gravel extraction site at Langtoft, Market Deeping was intended to be reclaimed for agricultural use. We were asked to examine the feasibility of using windmills to power drainage pumps.

The site, already partially worked, extends to some 40ha and drainage at present is by conventional pumping from 1600m of drainage ditch which can accept up to $1.4 m^3 m^{-1}$; eventually there will be 2500m of ditch.

Meteorologically there are two constraints on the scheme:-

1. Periods of light winds when the pumps will not operate or work only at much reduced efficiency.
2. Occasions of heavy falls of rain when pumping capacity may not be adequate to prevent flooding.

1. Periods of low wind speeds.

The proposed windmill was the Wakes and Lamb "Newark" windmill and while no starting speed is quoted from this windmill it is likely that at wind speeds of less than 10kt the pumping efficiency will decrease significantly. Allowing a very low starting speed (4kt), an examination of wind speeds at Wittering (about 15km southwest of the site) suggests that for more than 10% of the time the pumps will not work and for 50% of the time they will not reach full power. (Table 1) More important though is the length of spells of light winds. Although hourly data for wind speed are not available for Wittering, an impression of the scale of the problem can be gained from a table of spells of days with mean wind speed 10kt or less (Table 2).

The longest run in the 10 year period was 43 days, starting in June, but periods of 5 to 7 days when mean daily wind speed did not rise above 10kt are not uncommon - 79 such spells in 10 years.

An estimate of the probability of a spell may be obtained from Figure 1. If the mean wind speed today is 10kt or less then there is a 60% probability that low wind speeds will not last longer than 3 days and 75% probability that the spell will not extend to more than 5 days etc.

2. Heavy falls of rain

The quantity of water which can be stored in the ditches is $1.4 m^3 m^{-1}$. For the present 1600m of ditch the capacity is $2240 m^3$ increasing to $3500 m^3$ when the ditch length reaches 2500m. For a 40ha drained area these quantities represent 5.6mm and 8.7mm of rain fall respectively.

FH2B

The best pumping capacity quoted for this system is 2720 gallons per hour to a head of 25ft. At this pumping rate, equivalent to 12.36m^3h^{-1}, a single windmill would take just over 32 hours to pump out the water resulting from drainage of 1mm of rainfall when the soil is at field capacity.

On the assumption that the eventual agricultural use will be a cereals - roots rotation, we may use the 5-day rainfall expected once in 2 years (cereals) or once in 5 years (roots) as the design rainfall. The once in 5 year figure for Langtoft in winter is 45mm - higher in Summer but the excess can be assumed to be catered for in the buffering effect of soil moisture deficit in Summer.

Drainage design considerations assume this quantity to be delivered evenly over the 5 day period so the pumping requirement is 9mm of rain per day - 3600m^3 from 40ha. This would require 12 to 13 windmills (1 windmill every 200m of ditch) pumping at full efficiency throughout the whole 5 day period. On some occasions it is possible to regard the storage capacity of the ditches as providing a buffering effect to reduce the pumping requirement. The full storage represents just under one day of the design rainfall and, if it were available, would reduce the number of windmills required to 10.

However, the data assume that only rainfall from the 40ha reaches the drainage and that the pumps are always working at full efficiency. Should heavy rain occur in association with light winds and at a time when the ditches are already full it is unlikely that the system could cope.

It is unlikely that wind powered pumps could provide a viable alternative to conventional pumping - even when pumping capacity is increased. Nevertheless, with a better pumping rate they could provide useful fuel savings when used in conjunction with conventional pumping systems.

Any comments or criticism of this paper should be addressed to the author.

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TABLE 1

Percentage frequency of hourly wind speeds at Wittering 1970-79. (% by column)

Wind speed (kt)	J	F	M	A	M	J	J	A	S	O	N	D	Year
0-3	10.2	11.2	9.0	8.1	9.5	11.1	12.9	14.8	13.5	13.4	7.8	9.4	10.9
4-10	43.2	48.9	41.9	44.2	52.0	56.6	56.2	59.3	52.8	54.3	44.5	42.1	49.7
≥ 11	46.6	39.8	49.1	47.7	38.6	32.3	30.9	25.8	33.6	32.3	47.7	48.5	39.4

TABLE 2

Frequency of runs of days with mean wind speed 10kt or less at Wittering 1970-79

Length of run, days	Start of run (month) J	F	M	A	M	J	J	A	S	O	N	D	Total
1	19	14	18	17	12	12	12	8	11	11	27	15	176
2	8	6	11	11	13	5	7	4	2	7	6	9	89
3	7	10	2	9	11	8	4	7	4	3	5	4	74
4	2	5	4	2	9	5	3	1	4	1	3	5	44
5	1	2	3	3	5	4	4	4	1	4	3	1	35
6	4	1	3		1	1	3	4	1	2	3	1	24
7		3	1	3	1		2	1	6	1	1	1	20
8	1	4			3	1	3	4	3	2		1	22
9		1	1				1	2	1			2	8
10				1	1	1	2	2		4	1		12
11-15			1	1	1	4	1	4	2	3	1	1	19
16-25	1				1		1	1	2			1	7
≥ 26						2			1	1			4
Total	43	46	44	47	58	43	43	42	38	39	50	41	

CUMULATIVE % PROBABILITY (P) OF A SPELL OF LESS THAN N DAYS

WITTERING 1970-79 – DAYS WHEN MEAN WIND SPEED ≤ 10 kt.

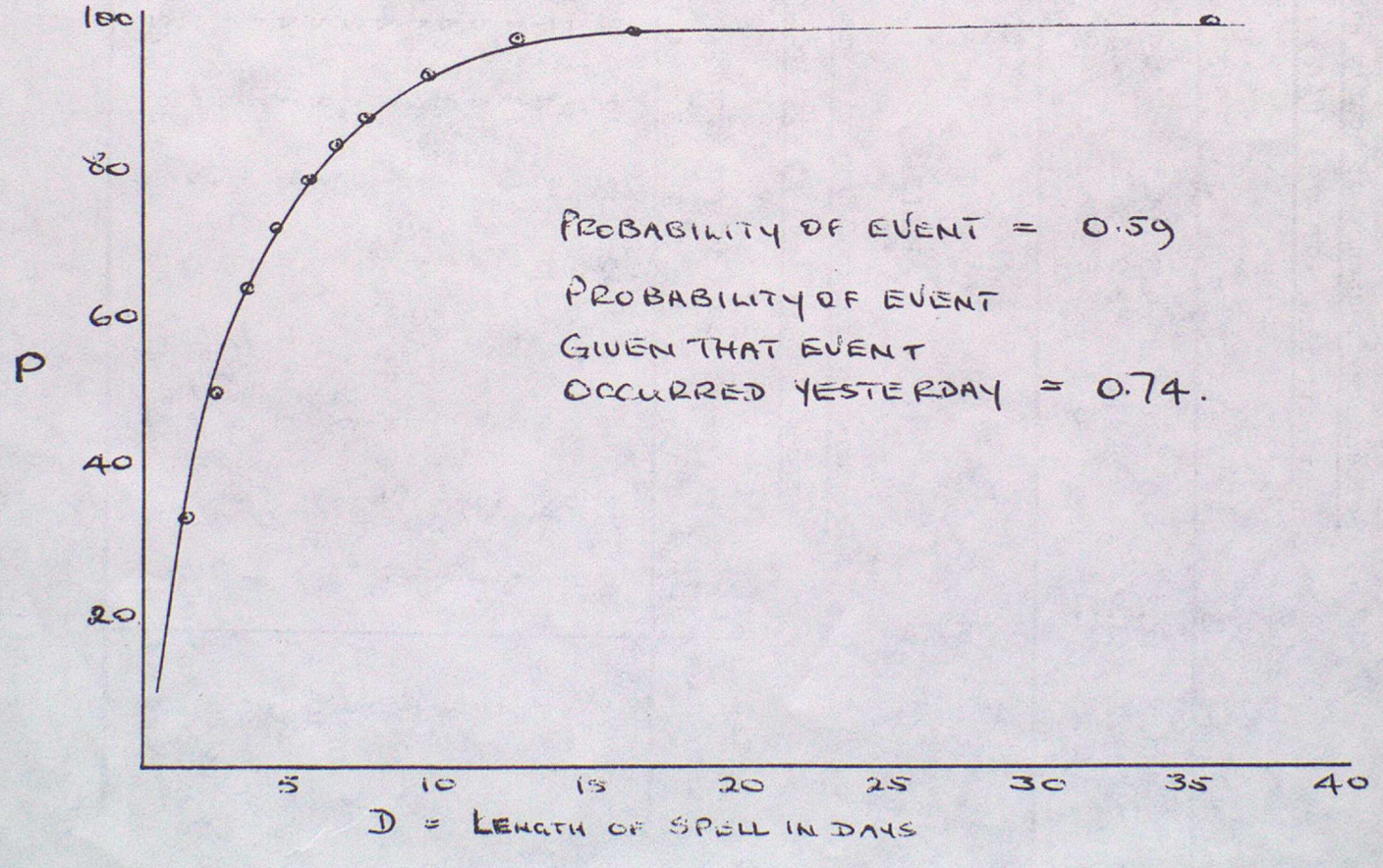

FIGURE 1.